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Compacted Concrete Paving (CCP) New Paving Technology for Paving Parking Areas, Local Roads, and Streets

Stan Bland, PE
Pavement Applications Director, Carolinas/Virginia

Andy Johnson, Ph.D., P.E.
Pavement Design Engineer

September 13, 2017
Tyson's Corner, VA

Introduction to Compacted Concrete Pavement

Roller Compacted Concrete without the rollers…

System	Durable	Low First Cost?	Aesthetically Pleasing

System	Durable	Low First Cost?	Aesthetically Pleasing
Asphalt	✗	✓	✓

System	Durable	Low First Cost?	Aesthetically Pleasing
Asphalt	✗	✓	✓
Concrete	✓	?	✓

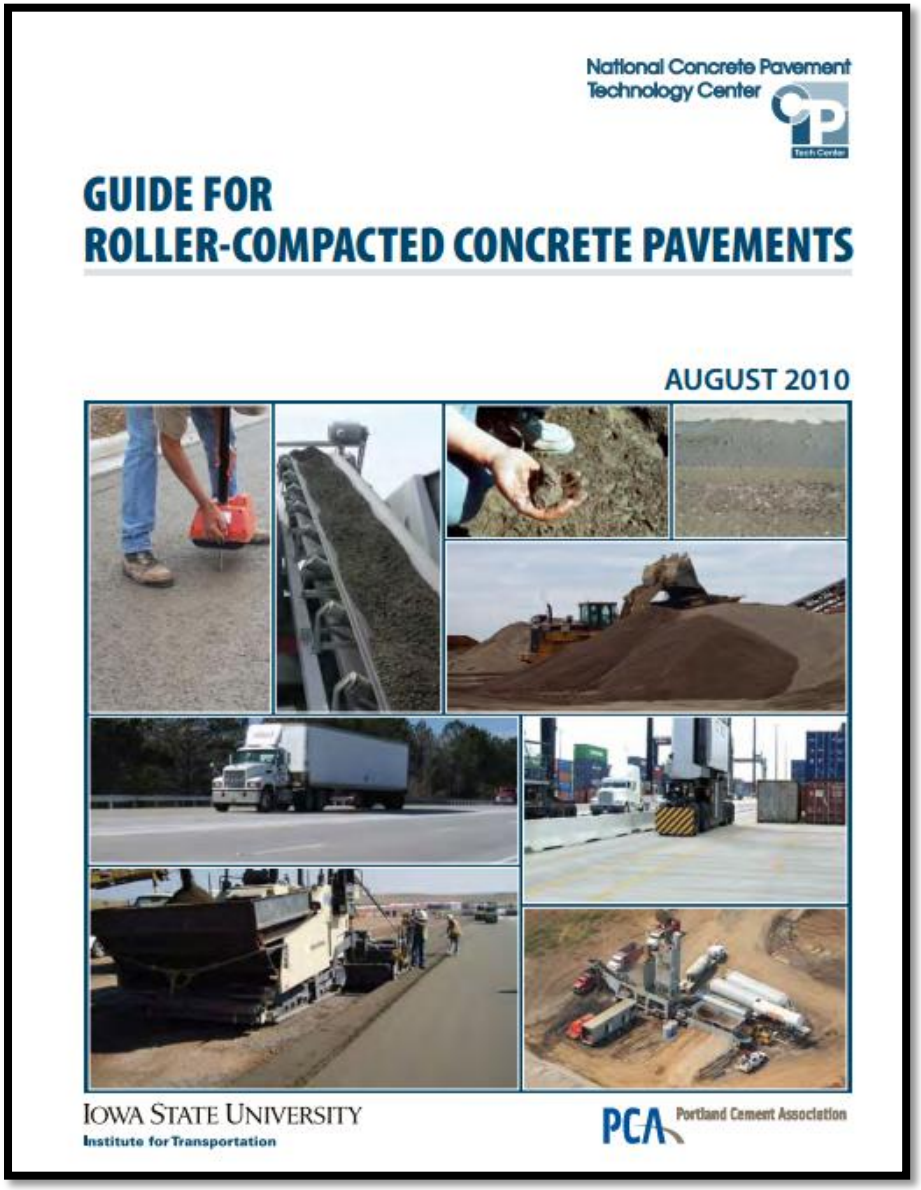
System	Durable	Low First Cost?	Aesthetically Pleasing
Asphalt	✗	✓	✓
Concrete	✓	?	✓
RCC	✓	✓	✗

System	Durable	Low First Cost?	Aesthetically Pleasing
Asphalt	✗	✓	✓
Concrete	✓	?	✓
RCC	✓	✓	✗
CCP	✓	✓	✓

RCC Definition

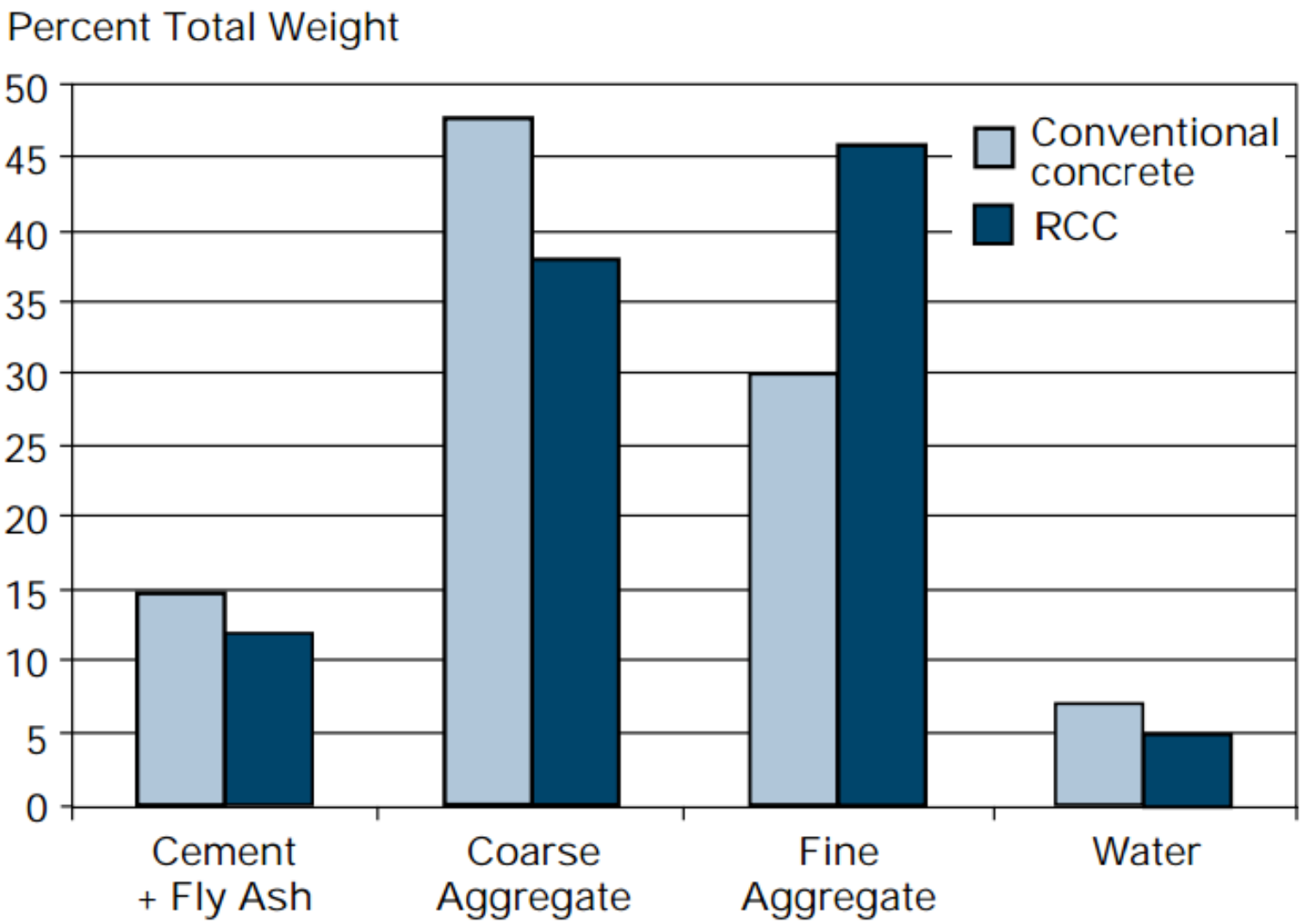
- "Roller Compacted Concrete (RCC) is a no-slump concrete that is compacted by vibratory rollers."
- Zero (or negative) slump
- No forms
- No reinforcing steel
- No finishing (typically)
- Placed by external force rather than internal vibration.

Concrete pavement placed in a different way!


National Concrete Pavement
Technology Center
GUIDE FOR
ROLLER-COMPACTED CONCRETE PAVEMENTS
AUGUST 2010
IOWA STATE UNIVERSITY
Institute for Transportation
PCA
Portland Cement Association

RCC pavement is a hybrid

- Conventional PCC Pavement
  - Uses the same materials (with different proportions)
  - Cured similarly
- Asphalt Pavement
  - Similar aggregate gradation
  - Similar construction methods


Percent Total Weight
50
45
40
35
30
25
20
15
10
5
0
Conventional concrete
RCC
Cement + Fly Ash
Coarse Aggregate
Fine Aggregate
Water

Where has RCC been used?

- Ports, intermodal facilities, heavy industrial areas subjected to greater-than-highway loading

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Coal ash landfill, Moncure, NC

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CSX Intermodal facility, Charlotte Airport, NC

Where has RCC been used?

- Ports, intermodal facilities, heavy industrial areas subjected to greater-than-highway loading
- Light industrial areas subject to highway loadings

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Celadon Trucking, Richmond, VA

Where has RCC been used?

- Ports, intermodal facilities, heavy industrial areas subjected to greater-than-highway loading
- Light industrial areas subject to highway loadings
- Local and arterial streets

Wichita, Kansas

Where has RCC been used?

- Ports, intermodal facilities, heavy industrial areas subjected to greater-than-highway loading
- Light industrial areas subject to highway loadings
- Local and arterial streets
- Logging facilities, composting areas, and storage yards

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Log handling yard

Where has RCC been used?

- Ports, intermodal facilities, heavy industrial areas subjected to greater-than-highway loading
- Light industrial areas subject to highway loadings
- Local and arterial streets
- Logging facilities, composting areas, and storage yards
- Highway shoulders

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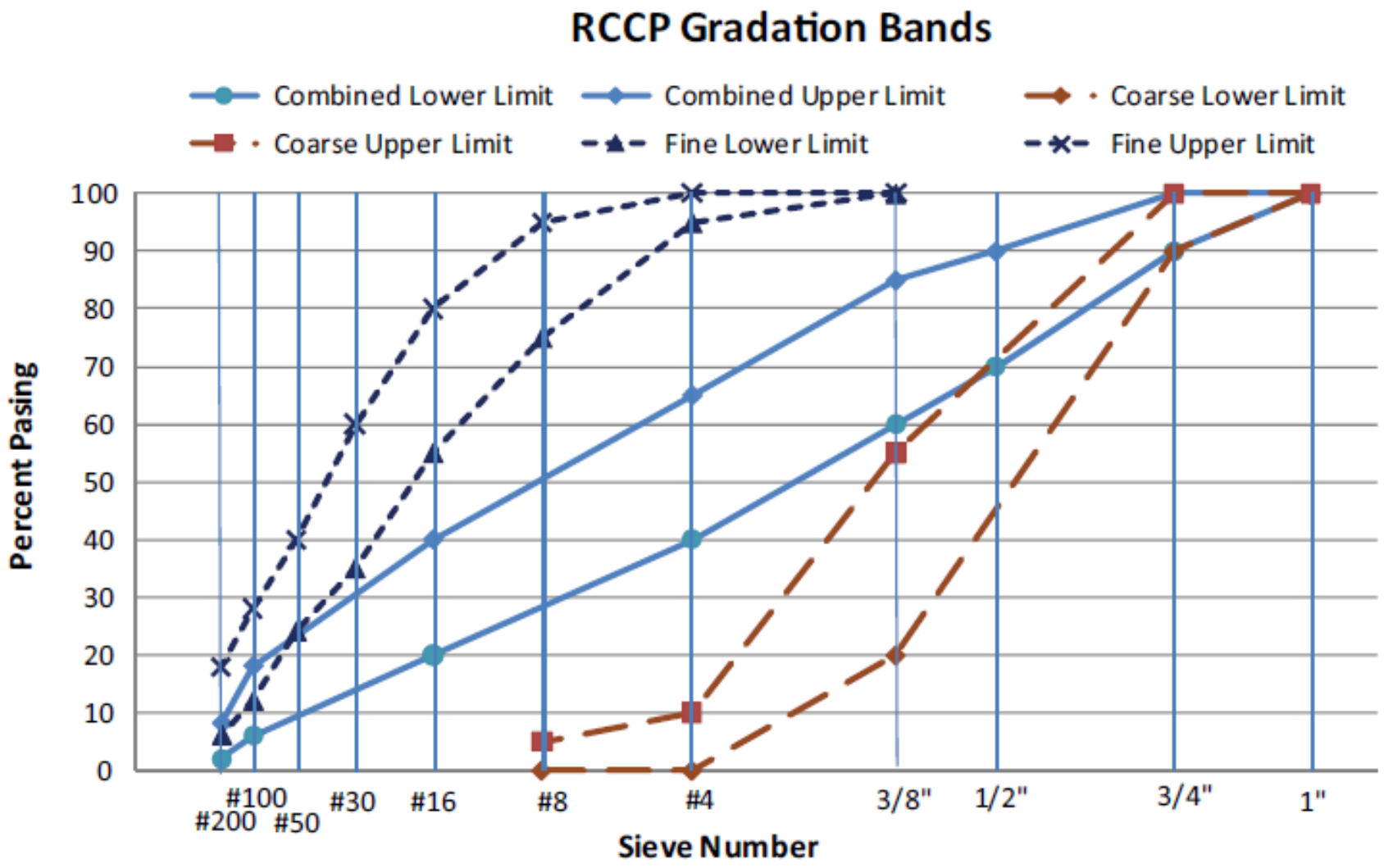
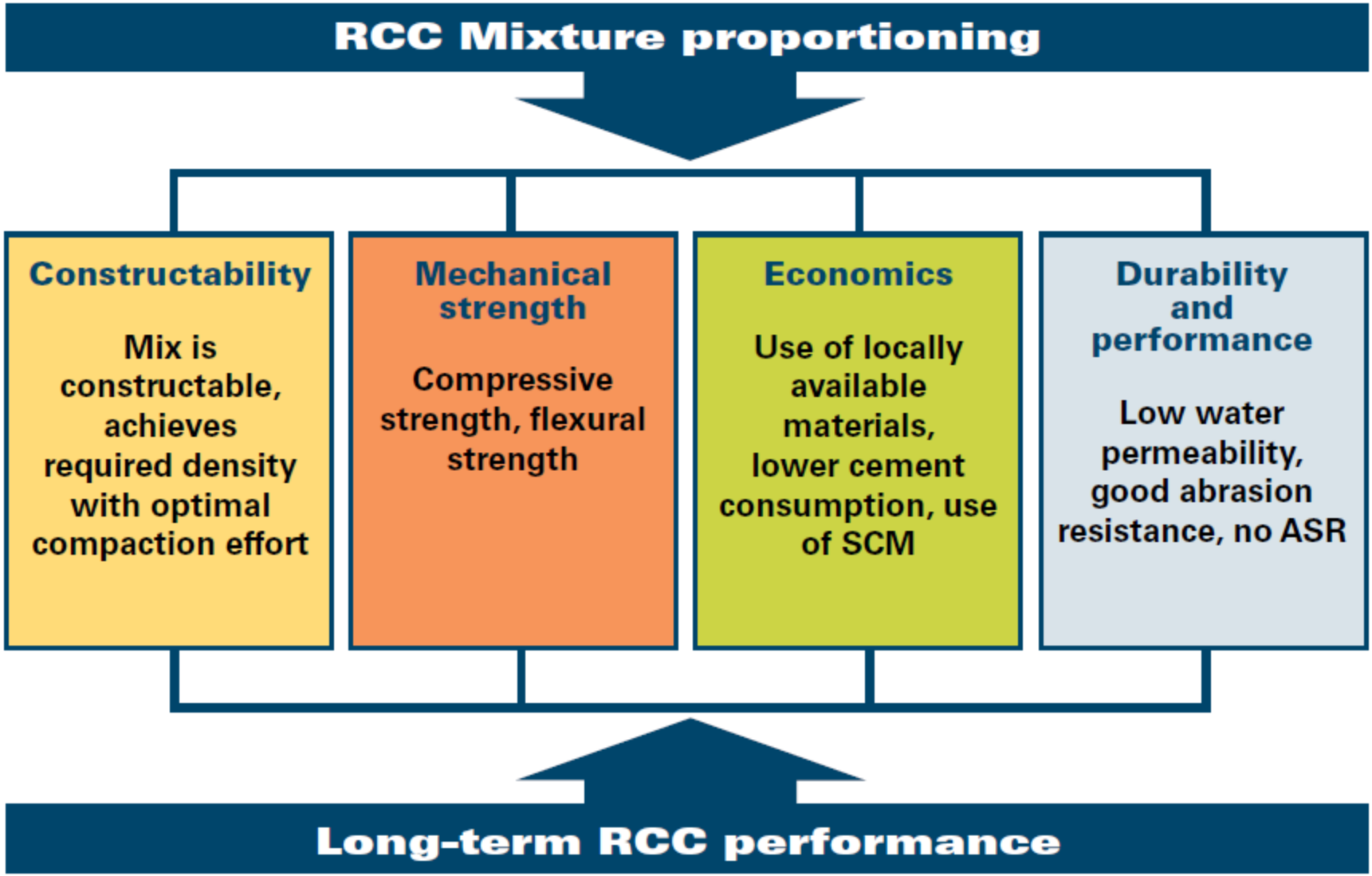
Interstate 385, Laurens Co., SC

RCC aggregate gradation

- Aggregate gradation essential to good mix performance
- Constructed like asphalt; needs to be graded like asphalt


RCCP Gradation Bands
Combined Lower Limit
Combined Upper Limit
Coarse Lower Limit
Coarse Upper Limit
Fine Lower Limit
Fine Upper Limit
Percent Pasing
100
90
80
70
60
50
40
30
20
10
0
#200
#100
#50
#30
#16
#8
#4
3/8"
1/2"
3/4"
1"
Sieve Number


RCC Mixture proportioning
Constructability
Mix is constructable, achieves required density with optimal compaction effort
Mechanical strength
Compressive strength, flexural strength
Economics
Use of locally available materials, lower cement consumption, use of SCM
Durability and performance
Low water permeability, good abrasion resistance, no ASR
Long-term RCC performance

Soil compaction proportioning method

- Choose well-graded aggregates
- Select a range of cementitious material contents
- Develop a moisture-density relationship
- Cast samples to measure compressive strengths
- Select cementitious material content to achieve desired strength


TE 805
TEST SPECIMEN - DO NOT DISTURB
DATE CAST
SET NUMBER
PROJECT
SLUMP/AIR/TEMP
REMARKS


HILTI TE 805

Structural design

- Completed RCC acts like plain, unreinforced, undoweled PCC pavement.
- Design is basically the same.
- Thickness range for 1 lift is 4 to 10 inches.
- Multiple lift construction is commonly used for loads substantially above highway legal loads.
- Thickness is a function of:
  - Number and weight of expected loads.
  - Flexural strength of concrete.
  - Subbase support

RCC Design Future? Results from LTRC's Accelerated Loading Facility

Tyson Rupnow, Ph.D., P.E.
Zhong Wu, Ph.D., P.E.

LTRC Project 12-7P

April 26, 2016

Spring TTCC/NCC Meeting, Columbus, OH

Distress Observed (6+8.5RCC) – Section 5

- **Visual Distresses**
  - Longitudinal cracks were observed along the wheel path and at the edge of the tire print
  - Pumping action was observed through cracks and joints
  - 87.4 million ESALs to failure
  - ***1.9 million ESALs predicted***

1.75 million Passes

Distress Observed (4+8.5RCC) – Section 6

- **Visual Distresses**
  - Longitudinal cracks were observed along the wheel path and at the middle of the tire print
  - Pumping action was observed through the cracks and joints
  - 19.2 million ESALs
  - ***0.7 million ESALs predicted***

Pavement Condition at the end of testing

Commonly used design procedures

- PCA Method
  - Single vehicles
  - Industrial pavements
  - Currently only available as manual procedure in Bulletin IS-233
  - Online design tool being deployed by ACPA in near future.
- US Army Corps of Engineers Method
  - Single vehicles
  - Computer program PCASE
  - Good for aircraft, tracked vehicles and unconventional loading
- Conventional concrete design procedures
  - Mixed traffic
  - ACI 330/ACI 325.12R (based on ACPA/PCA design methods)
  - AASHTOWare PavementsME
  - ACPA StreetPave (also being included in online design tool)

How is RCC produced?

- Generally three types of available mixing operations:
  - Continuous Flow Pugmill
  - Dry Batch Plant
  - Rotary Drum Mixing Plant

Continuous Mix Pug Mill

- High-volume applications
- Excellent mixing efficiency for dry materials
- 250 to 900+ tons/hr
- Mobile, erected on site
- Mobilization costs

Rotary Drum Mix Plants

- Available at some locations.
- Mobilization issues.
- Capacity reduced due to low water content of mixture.

Dry batch plant

Dry batch plant

Dry batch plant

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Dry batch plant

Transporting and placement

Transporting and placement

Transporting and placement

- Layer Thickness
  - 4 in. Minimum Thickness.
  - 9 – 10 in. Maximum Thickness in a single lift.
- Timing Sequence
  - Adjacent lanes placed within 60 minutes for “fresh joint”
  - Multiple lifts placed within 60 minutes for “fresh joint”
- Production should match paver capacity
  - Continuous forward motion for best smoothness

Transporting and placement

- Haul Time
  - Can vary widely depending on weather
  - Specification requires 45 minute maximum
  - Admixtures can greatly increase haul time

High density pavers

- Vibrating screed
- Dual tamping bars and or pressure bars
- High initial density, 90-95%
- Reduces subsequent compaction
- High-volume placement (1,000 to 2,000 cubic yards per shift)
- Designed for harsh mixes
- Smoothest RCC surface

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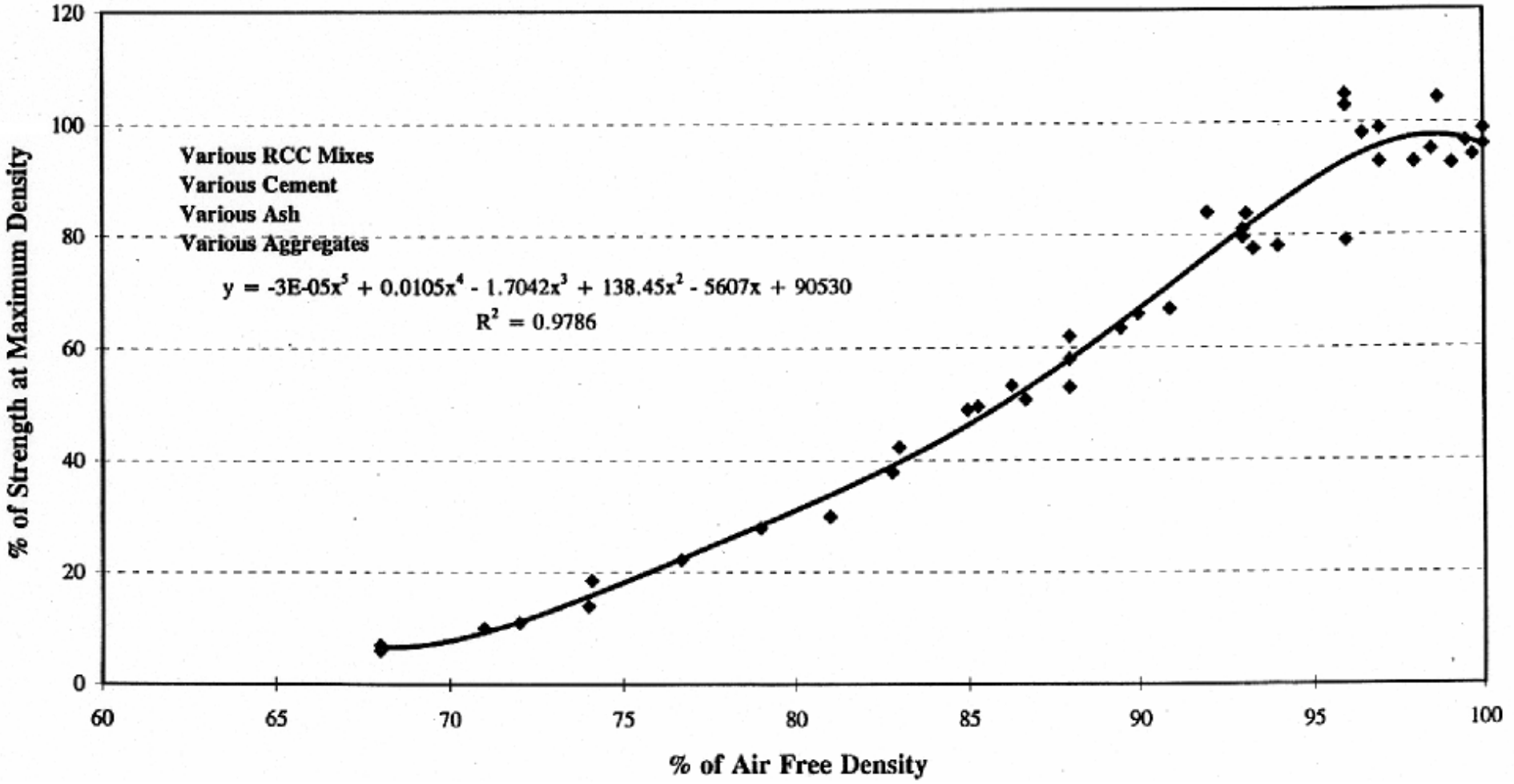
High Density Pavers

Compaction-Final Density

- Final density is critical for strength and durability
- Compacted to 98% modified Proctor (typical)
- Dual steel drum roller
- Combination roller
- Rubber coated steel drum roller
- Rubber tire roller

Compaction is critical




GDOT

Transverse Joints

Early entry saw

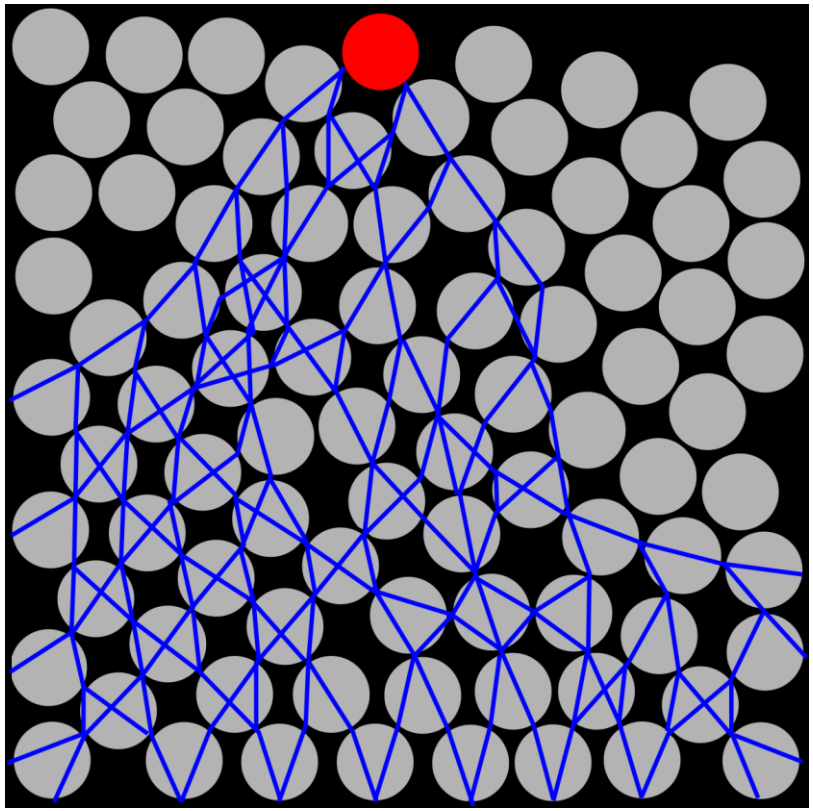
Depth D/4 to D/3

Curing

- Extremely important; Ensures surface durability
- Low moisture content in RCC dictates moisture retention.
- Three methods:
  - Moist Cure
  - Concrete Curing Compound
  - Asphalt Emulsion

Opening to traffic

- Because RCC is compacted, it behaves like a granular solid prior to hydration.



Opening to traffic

Opening to traffic

Opening to traffic

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Opening to traffic

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Opening to traffic

Opening to traffic

Sounds great, what's the catch?

Surface Appearance

- Not as smooth as conventional concrete
- Important to recognize difference
- Similar appearance to asphalt only light grey instead of black

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Surface Texture

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Crossgate Rd., Port Wentworth, GA

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Hampton Inn Parking Lot, Glen Allen, VA

Compacted Concrete Pavement

- ACEiT admixture/finishing system
- Consists of a dry powder added during mixing and surface-applied curing compound/hardner (ACEiT Blue)
- Admixture has several functions:
  - Reduces energy necessary for compaction, typically achieving 95%-98% without rolling
  - Puts the concrete to sleep until external energy is applied, greatly increasing haul time
- In conjunction with admixture, surface compound
  - Allows finishing with power trowel and broom
  - Provides smoother surface with enhanced consistency

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s, GA

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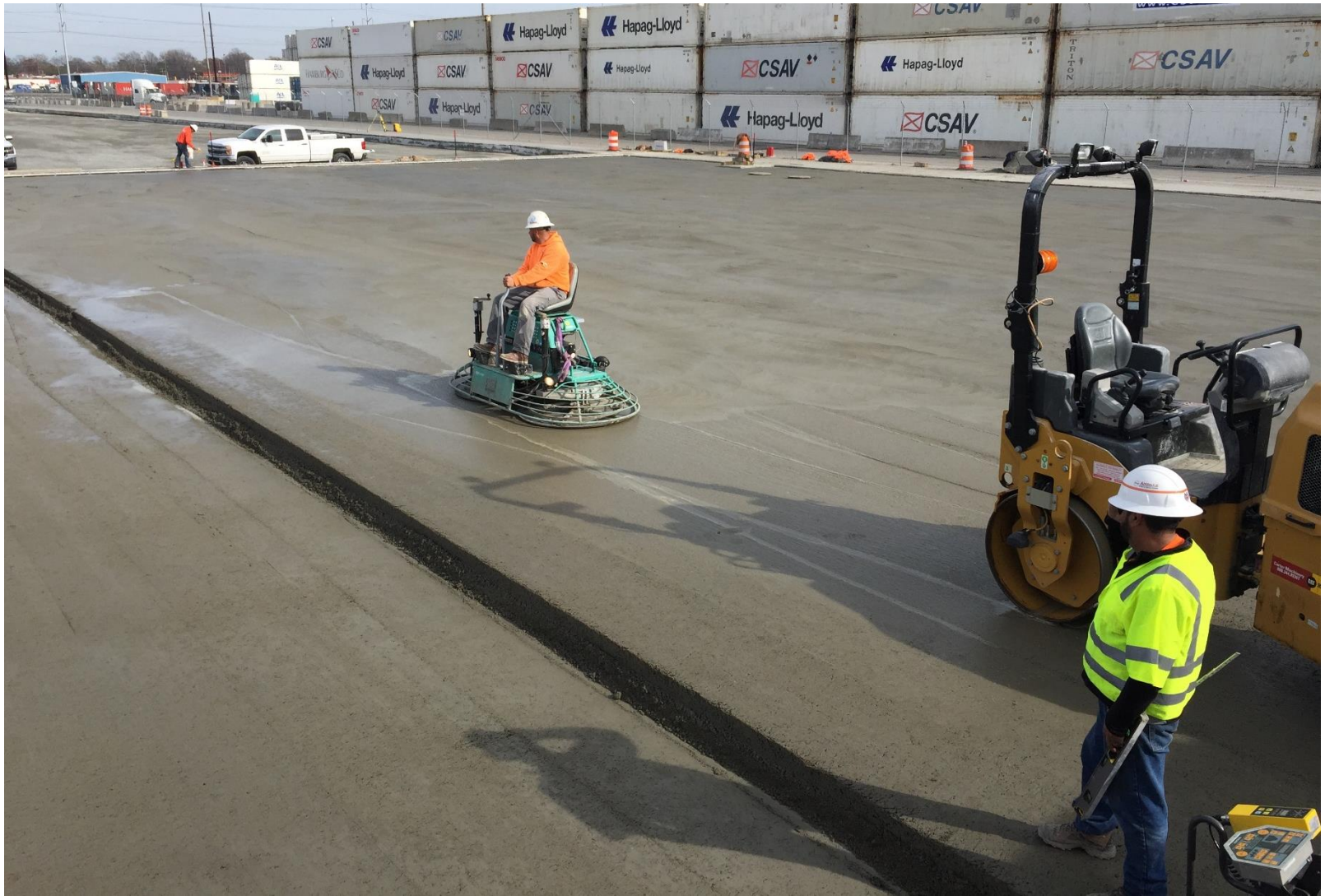
Norfolk International Terminal



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Norfolk International Terminal

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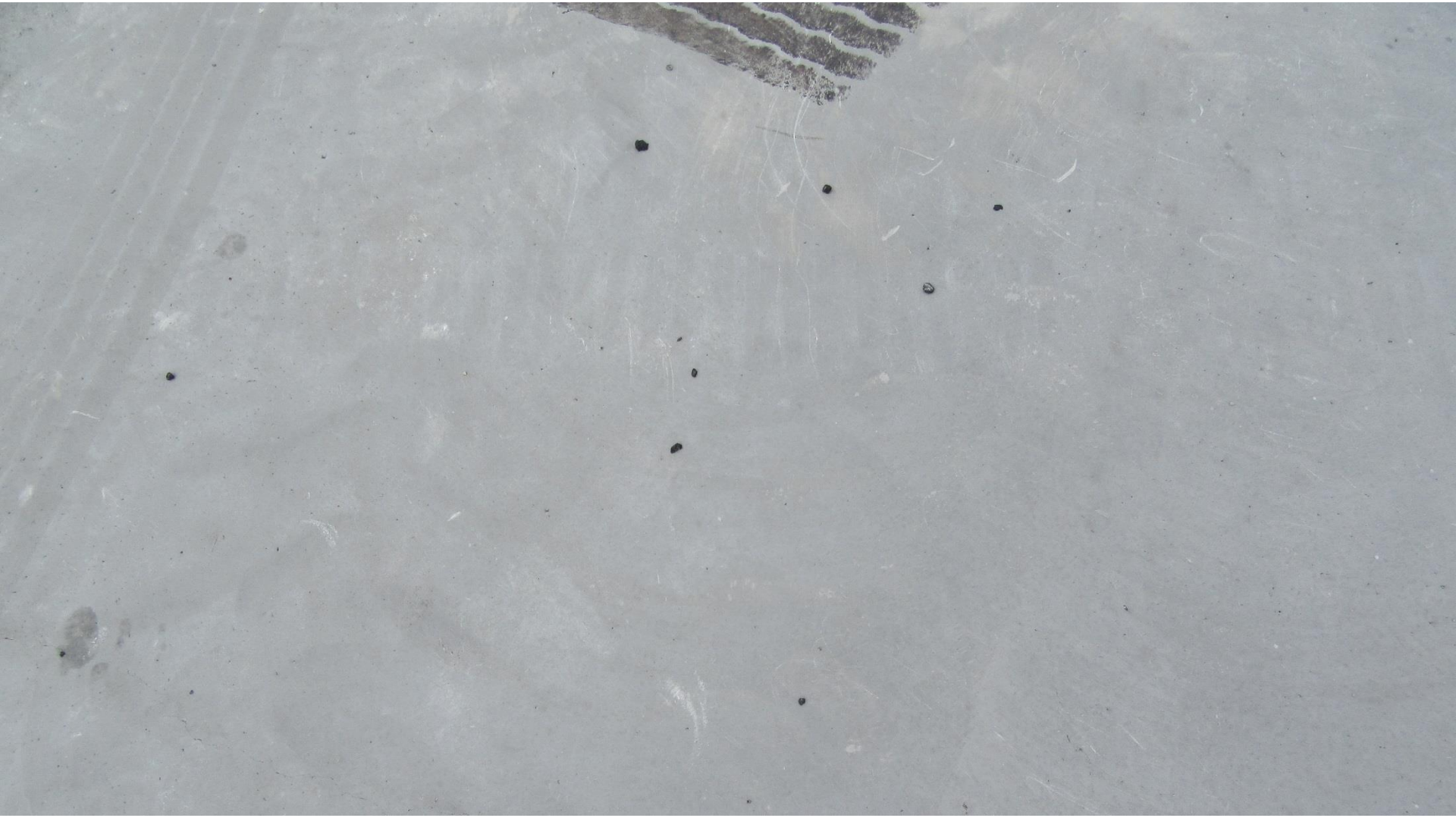

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Norfolk International Terminal

I-85, Greensboro, NC

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RTP500
ANDALE
CONSTRUCTION

Thank you!

Stan Bland, PE

Pavement Applications Director – Carolinas/Virginia

sbland@cement.org

704-975-2951

Andy Johnson, Ph.D., PE

Pavement Design Engineer

ajohnson@cement.org

803-556-2889